First inventory of the introduced and invasive mollusks in Mexico

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ABSTRACT

Early historical records are included in this first national inventory of species of mollusks introduced, whether intentionally or not, into Mexico by humans. Of the 56 exotic-invasive mollusks listed, 15 inhabit brackish and marine environments, 10 freshwater, and 31 are terrestrials. Thirty-six per cent of the introduced species come from Europe and the Mediterranean, 18% from Asia-Australia-New Zealand, 46 % are cryptogenic, coming from different regions of the planet, and the origin of several others is uncertain. The best-represented families are Mytilidae, Teredinidae (brackish and marine), Ampullariidae, Thiaridae, and Planorbidae (freshwater), and Helicidae, Agriolimacidae, Limacidae, Subulinidae, and Vallonidae (terrestrial). They involve *Mytilus galloprovincialis* Lamarck, 1819, *Pomacea canaliculata*, Lamarck, 1819, and *Dreissena polymorpha* (Pallas, 1771), species included among the world´s worst invasive species. Some have become naturalized: three brackish and marine species, six freshwater, and twelve terrestrial. The increase in exchange of goods, services, and transport has assisted in the transfer of species from distant places, as has intentional or unintentional introduction of species of economic importance (*M. galloprovincialis*, *Crassostrea gigas* (Thunberg, 1793), *C. sikamea* (Amemiya, 1928)), without consideration of the epibionts, endobionts, and endoparasites that may also be introduced. Effective strategies must be developed to minimize the potential impact of biological invasions and raise public awareness of the problem; this must include the rigorous application of more stringent regulations.

Additional Keywords: exotic, freshwater, terrestrial mollusks, marine, mollusks, economic and biological risks

INTRODUCTION

Biological contamination in the world has increased markedly since 2000 (Crocetta et al., 2013), Pimentel et al. (2001) estimated that some 480000 species have been introduced around the world throughout the history of humankind, and this is of great concern. The effects that alien species may have in ecosystems (Carlton, 1999) and in their interaction with native organisms are poorly understood; however, we face loss of diversity (Reyna et al., 2013) of formerly diverse ecosystems (Cowie, 1998, 2001; Cowie and Robinson, 2003; López-López et al., 2009). It may be possible that endemic species are the most vulnerable, although unfortunately, knowledge of the diversity and abundance of much of the world's fauna remains unsatisfactory. In Mexico, where it is estimated that 75 % of brackish and marine species are known, it is suggested that 17 % of the Pacific species, and 15% of those in the Gulf of Mexico and the Caribbean Mexican coast are endemic (Castillo-Rodríguez, 2014). On the other hand, fewer than 35 % of the native non-marine mollusks are known and 85% of the Mexican territory is in need of exploration (Thompson, 2011).

In the case of the introduction pathways at global level, marine vectors are well documented. Mexico has a navigation infrastructure that facilitates the introduction of alien species; human activities on the continental margins, and in the bays and estuaries of the coastal zone, have evolved since the 16th century and are now part of an impressive network of global marine traffic. Currently there is the threat of climate change, which will undoubtedly alter the structure and composition of native communities. This will also alter the functioning of ecosystems and become a stressor that will further increase the risk of biological invasions in marine and non-marine systems. The effects of climate change on the environment will include substantial impact on native species. Given the increase in threats to the native fauna, inventories of exotic species become the foundation for future actions, including the control and eradication of invasives (Mendoza et al., 2014). This article offers a review of the brackish-marine and non-marine introduced mollusks in Mexico, constituting the first national inventory of this type elaborated in Mexico; it also determines the naturalized species at the national level. We examine potential vectors and recommend measures that may help prevent the entry of additional alien organisms and that could help control and serve as essential protective measures for the fauna and the environment at the national level in Mexico.

Early Records of Introduced Mollusks in Mexico

In relation to introduced non-marine mollusks, *Cornu aspersum* (Müller, 1774) (as *Helix aspersa* Müller, 1774) was detected in Mexico by Alexander Humboldt between 1803 and 1804 (Martens 1890–1901); and it was recorded by Pilsbry (1891) in Mexico City. It was also located in Jaral, Guanajuato, and other unspecified sites (Martens 1890–1901). The species became a pest in gardens throughout Mexico City (Ancona, 1947) and was later recorded at Chapultepec, and in mountains between Mexico City and the city of Cuernavaca (Jacobson, 1952). Baker (1925) mentioned the presence of *Phyllocaulis gayi* (Fischer, 1871) in Mazatlán, Sinaloa. Andrews and Dundee (1987) stated for the first time the problems caused by the slug *Sarasinula plebeia* (Fischer, 1868) in Chiapas (1980) and Veracruz (1981), and Naranjo-García et al. (2007) reviewed the distribution of the family Veronicellidae nationwide, with particular reference to *Sarasinula plebeia* (= *Sarasinula dubia* (Semper, 1885)). As for other introduced slugs, Cockerell (1923) recorded *Limacus flavus* (Linnaeus, 1758) (as *Limax flavus* Linnaeus, 1758) with numerous individuals or populations in Mexico City. After that, Baker (1930) found various European slugs (*Limax maximus* Linnaeus, 1758 in Desierto de Los Leones to Cuajimalpa; *L. flavus* in Huachinango, Puebla; *Deroceras laeve* (Müller, 1774) (aphallic) in Desierto de Los Leones and Necaxa; *D. laeve* (phallic) (Müller, 1774) in Cuajimalpa and San Juan Teotihuacan; and *Milax gagates* (Draparnaud, 1801) in Desierto de Los Leones. The Cuban species *Zachrysia auricomya havanensis* Pilsbry, 1894 was recorded in Yucatan (Bequaert and Clench, 1936) and *Vallonia excentrica* Sterki, 1893 was found by Joshua L. Baily Jr. in Cuernavaca (Pilsbry, 1948).

The freshwater clam *Corbicula fluminea* (Müller, 1774) (as *Corbicula manilensis* (Philippi, 1844)) was recorded in Baja California, northwestern Mexico (Fox, 1970) and Hillis and Mayden (1985) summarized its distribution along the coastal areas of Pacific and in the State of Tamaulipas; it was later recorded in Lake Catemaco, southern Veracruz (Torres-Orozco and Revueltas-Valle, 1996). The freshwater snail *Melanoides tuberculata* (Müller, 1774) was found in the vicinity of Veracruz in 1973 (Abbott, 1973), and its presence in Mexico was confirmed in 1975 by Pointier and McCullough (1989). More details of its distribution in Mexico have subsequently emerged (Contreras-Arquieta, 1998; Contreras-Arquieta and Contreras-Balderas, 2000; Contreras-Arquieta, et al. 1995). The first record of *Tarebia granifera* (Lamarck, 1822) was at Lake Catemaco, Veracruz (Naranjo-García et al., 2005), and other foci were later found in northern Veracruz State (López-López et al., 2009), in southern Oaxaca State, and in the Lacandona Forest, Chiapas (Naranjo-García non-published data); it was later recorded from 11 lakes of three municipalities in the State of Tabasco (Rangel-Ruiz et al., 2011).

The terrestrial species *Rumina decollata* (Linnaeus, 1758) was recorded in 1993 in the States of San Luis Potosí and Tamaulipas (Correa-Sandoval, 1993, 1998; Correa-Sandoval and Rodriguez, 2002), and soon afterward in Nuevo Leon (Correa-Sandoval 1999b; Correa-Sandoval and Rodríguez, 2005; Correa-Sandoval et al., 2007). *Huttonella bicolor* (Hutton, 1834) (as *Gulella bicolor* (Hutton, 1834)) was collected at the archaeological site El Tajin, Veracruz (Correa-Sandoval, 1999a, 2000).

In relation to marine mollusks introduced into Mexican waters, Hendrickx (1980) and Salgado-Barragán and Toledano (2006) provided data from specimens observed *in situ* and preserved in the Invertebrate Collection (EMU) of Unidad Académica of Mazatlán, Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México. There are also other published records: for example, Okolodkov et al. (2007) and Ortiz-Arellano and Salgado-Barragan (2012). According to Carlton (1999), the diversity and abundance of exotic and invasive marine species at worldwide level are still poorly known; this is certainly true for Mexico, where lack of awareness of the presence of exotic species is compounded by unfamiliarity of their effects on the ecosystems.

MATERIALS AND METHODS

The present compilation was assembled based on records of mollusks deposited in: Colección Nacional de Moluscos (National Collection of Mollusks), Instituto de Biología, Universidad Nacional Autónoma de México); database of the Invertebrate Zoology division of the Florida Museum of Natural History, FLMNH; the Unidad Académica of Mazatlan of the Instituto de Ciencias del Mar y Limnología (ICMyL-MAZ, UNAM); the literature; field observations by the authors and/or other specialists; a list of organisms coming from Mexico and intercepted at customs upon arrival in the USA; and additional information provided by David Robinson (letter to E. Naranjo-García, 4 September 2014). In certain cases, where the literature is very extensive, the first and the most recent articles or references were selected. Acronyms used are: CNMO, Colección Nacional de Moluscos, Universidad Nacional Autónoma de México; CM, Carnegie Museum of Natural History, Pittsburgh; FLMNH, database of the Florida Museum of Natural History, Gainesville; EMU, Colección de Invertebrados, Unidad Académica de Mazatlán del Instituto de Ciencias del Mar y Limnología.

RESULTS

In total, 56 species of exotic-invasive mollusks from the classes Bivalvia and Gastropoda have been so far introduced into Mexico, whether intentionally or not: 15 brackish–marine, 10 freshwater, and 31 terrestrial mollusks (Tables 1, 2, and 3). Of these, 36 % came from Europe and the Mediterranean (the majority are terrestrial mollusks), 18 % from Asia- Australia-New Caledonia

Table 1. Exotic estuarine marine mollusks recorded in Mexico: place of origin, references or sources, means of introduction (vector), and habitat;* = Naturalized.

Family	Species	Origin	Source	Vector	Habitat
Arcidae	*Anadara transversa* (Say, 1822)*	Northwestern Atlantic from Cape Cod to Texas, USA.	Laguna de Tamiahua, Veracruz, (García- Cubas, 1969; Abbott, 1974); Tamaulipas shore (Correa-Sandoval and Rodríguez-Castro, 2013)	Ballast water/ escorting fauna of economically important species	Estuarine-marine
Mytilidae	*Arcuatula senhousia* (Benson in Cantor, 1842)	Asia (Japan and China)	Estero de Punta Banda, Baja California (Cohen, 2005)	Ballast water/ Aquaculture	Estuarine-marine
Teridinidae	*Bankia destructa* Clench and Turner, 1946	Caribbean	Laguna Caimanero, Sinaloa (Hendrickx, 1980)	Regional and cosmopolitan distribution hydraulic transport	Estuarine-marine
	Bankia zeteki Bartsch, 1921	Caribbean (Panama and Colombia)	Teacapan, Mazatlan, Sinaloa (Hendrickx, 1980)	Regional and cosmopolitan distribution hydraulic transport	Estuarine-marine
Pyramidellidae	*Boonea bisuturalis* (Say, 1822)	Delaware, Canada and Massachusetts, New York, USA	Arrecife Lobos, Veracruz (De la Cruz and González, 2006)	Aquaculture (polluted oysters)	Estuarine-marine
Littorinidae	*Cenchritis muricatus* (Linnaeus, 1758)*	Gulf of Mexico, Caribbean, the Antilles, Costa Rica, Cuba, Panama, Puerto Rico, Venezuela	Gulf of California (Carlton 1992, Bishop, 1992; Chaney, 1992)	Regional and cosmopolitan distribution hydraulic transport	Marine
Ostreidae	*Crassostrea gigas* (Thunberg, 1793)*	Japan and Korea	Bahía San Quintín, Baja California (Islas-Olivares, 1975)	Aquaculture	Marine
	Crassostrea sikamea (Amemiya, 1928)	China	San Quintín, Baja California (Cáceres-Martínez et al., 2012)	Aquaculture and coastal transports	Marine
Mytilidae	*Geukensia demissa* (Dillwyn, 1817)	North-eastern America	Estero Punta Banda, Baja California (Torchin et al., 2005)	Aquaculture and coastal transports	Estuarine
Dreissenidae	*Mytilopsis adamsi* Morrison, 1946	Native to tropical west Pacific of Central America	Estero Urías, Mazatlán (Salgado-Barragán and Toledano-Granados, 2006)	Aquaculture	Estuarine
Mytilidae	*Mytilus galloprovincialis* Lamarck, 1819	Mediterranean, Black sea and Adriatic sea	Bahía de Todos los Santos, Baja California (Curiel-Ramírez and Cáceres-Martínez, 2009)	Aquaculture	Estuarine-marine
	Perna perna (Linnaeus, 1758)	Indo-Pacific Region	Gulf of Mexico, Veracruz (Hicks and Tunnell, 1995); Tamaulipas coast (Correa and Rodríguez, 2013)	Ballast water	Estuarine-marine
Teridinidae	*Teredo bartschi* Clapp, 1923	South of Carolina to Texas, USA. and Bermuda	Laguna Caimanero, Sinaloa (Hendrickx, 1980)	Regional and cosmopolitan distribution hydraulic transport	Marine
	Teredo navalis Linnaeus, 1758	Mediterranean-Europe -Western Atlantic	Cancun, Quintana Roo, FLMNH year 1987-CN: 349169-Mollusca; Bahía de Campeche (López-Garrido, 2008)	Ballast water	Estuarine-marine
Semelidae	*Theora lubrica* Gould, 1861	Asia (South of Japan to Singapur and Indonesia)	Tijuana-Ensenada, Baja California (Carpizo-Ituarte and Rodríguez, 2009)	Ballast water	Estuarine-marine

*Naturalized

(several estuarine/brackish- marine and some freshwater species), 46 % from different regions of the planet (Table 4), with the place of origin of several being uncertain.

Most of the brackish and marine species (Table 1) belong to the families Mytilidae and Teredinidae (Bivalvia). Among the freshwater mollusks (Table 2), gastropods are the dominant group, in particularly species in the families Ampullariidae, Thiaridae, and Planorbidae. Most of the terrestrial mollusks (Gastropoda) (Table 3) belong to the family Helicidae, followed by the Agriolimacidae, the Limacidae, the Subulinidae, and the Vallonidae. The species that have been recorded only once are: *Theora lubrica* Gould, 1861 (marine), *Helisoma duryi* (Wetherby, 1879) (as *Planorbella duryi* (Wetherby, 1879)) (freshwater), and *Phyllocaulis gayi*, *Cecilioides acicula* (Müller, 1774), *Arion circumscriptus* Johnston, 1828, *Vallonia costata* (Müller, 1774), *Zachrysia auricomya havanensis*, and *Cantareus apertus* (Born, 1778) (as *Helix aperta* Born, 1778) (terrestrial).

DISCUSSION

Marine Mollusks

The ecosystems that now are home to exotic mollusks are vulnerable to changes in their composition, regardless of whether those mollusks were introduced inadvertently or for commercial purposes. Especially threatening are those species that have been restricted to environments disturbed either naturally or by human intervention, as is the case of brackish and marine mollusks such as *Mytilus galloprovincialis* Lamarck, 1819 (Mytilidae). *Mytilus galloprovincialis*, originally from the Mediterranean, Black Sea and Adriatic Sea, has been categorized as one of the 100 worst invasive alien species of the world. Despite this, the species is cultivated for food in the states of Baja California Norte and Sur, and this is without any knowledge of its ecological impact on the native species. Populations of the mussel *Perna perna* (Linnaeus, 1758) are distributed from Texas to southern Veracruz State, Mexico (Hicks and Tunnell, 1993, 1995; McGrath et al., 1998), and Hicks et al. (2001) consider that its occurrence on Mexican coasts should be carefully monitored.

Mussels and shipworms can survive tough conditions in variable estuarine and marine environments, as well as in sheltered sites that may be favorable to their development and dispersal: they are adapted to this survival by their sessile habit, their filter feeding, and their modes of reproduction, growth, and morphological protection ((McDonald and Koehn, 1988; Turner, 1966; Tuente et al., 2002; Petes et al., 2007; Didziulis, 2007).

The shipworms, such as *Teredo navalis* Linnaeus, 1758, bore into submerged wood substrata all over the world, and there are few records of the species in Mexico. López-Garrido (2008) recorded the species from sunken boats in the state of Campeche, in the southern Gulf of Mexico. There are also references from the early 1900s (Dublán and Lozano, 1901; Mariscal, 1902) regarding requirements of the asphalt composition in Submarine Telegraph cables between the port of Veracruz and Campeche in order to avoid damage caused by the "marine worm", *T. navalis*. More recently, there are checklists, reports and theses records of its presence in estuaries on the Mexican coast of the Gulf of Mexico, such as the Tampamachoco Lagoon, Veracruz (without reference code), where it has been an element of the epibiosis on the mangrove *Rhizophora mangle* Linnaeus, 1753 since 1980.

Oysters of Asian origin, *Crassostrea gigas* (Thunberg, 1793) and, more recently, *C. sikamea* (Amemiya, 1928), are cultivated in Baja California Norte and Sur in Mexico. Sessile oysters adhering by cementing to any hard substratum, together with the large accompanying fauna on the surface of their shells, represent a potential risk to wildlife; hence, a study of their ecological impact would be most important. *Crassostrea gigas* exists as an exotic species on the southern Pacific coast and, since uncontrolled introduction is possible through ballast water and aquaculture practices, it might also be expected to eventually be introduced along the southern Gulf of Mexico, in locations as Veracruz State.

Anadara transversa (Say, 1822), a clam from the northwestern Atlantic, is considered a non-invasive exotic species. It was recorded in Tamiahua lagoon, Veracruz by García-Cubas (1969) and Abbott (1974). Although there are no recent records of substantial living populations, abundant disjointed valves have been reported.

Theora lubrica Gould, 1861, originally from Asia, is considered as one of the most important invasive species in Europe (Balena et al., 2002). According to Steneck and Carlton (2001), it is one of the 15000 species that have been transported across the world in ballast water. It is recorded from Baja California Norte, where it possibly arrived secondarily introduced from San Francisco Bay, USA; it can be considered a potentially invasive species for the Pacific States of Mexico.

There are fewer records of exotic marine gastropods species in Mexico than of exotic bivalve species. Among these gastropods is the pyramidellid *Boonea bisuturalis* (Say, 1822), a native of the northern coast of the Atlantic (Canada and USA) that feeds on the body fluids of invertebrates (Fretter and Graham, 1949; 1962; Fretter, 1951), including polychaetes, gastropods, and bivalves, and minor groups such as polyplacophorans and some echinoderms (Robertson and Orr, 1961). The Mexican coast of the Gulf of Mexico houses marine resources that include the Eastern Oyster *C. virginica* (Gmelin, 1791), which represents 90% of the catch produced along that coast (Cáceres-Martinez and Vásquez-Yeomans, 2013). Despite studies on diseases and ectoparasites of *C. virginica* in Mexico (Aguirre-Macedo et al., 2007; Cáceres-Martinez and Vásquez-Yeomans, 2013), a study of non-native endo- and ecto-parasites of mollusks in the coastal lagoons and coral reefs of the southern gulf is still lacking. However, *B. bisuturalis* (Say, 1822) has been registered by De la Cruz and González-Gándara (2006)

Table 2. Exotic freshwater mollusks recorded in Mexico, where are shown: place of origin, references or source, means of introduction (vector), habitat and impact with regard to the damage they may cause;* = Naturalized,** = data provided by David G. Robinson.

Family	Species	Origin	Source/ record CNMO	Vectors	Habitat	Impact
Ampullariidae	*Pomacea canaliculata* (Lamarck, 1822)*	Argentina, South America	Thiengo et al., 1993; Campos et al., 2013, Rawlings et al., 2007	Aquarium trade/ food trade (Rawlings et al., 2007)	Diverse bodies of water w/ abundant vegetation	Harmful
	Pomacea diffusa Blume, 1957**	Santa Cruz, Bolivia, South America	Specimens caught at the USA and Mexico border, place of dwelling unknown (Robinson, 2014, pers. comm.)	Aquarium trade / food trade	Diverse bodies of water w/ abundant vegetation (Cowie et al., 2006)	Potential pest
	Pomacea flagellata (Say, 1829)*	Gulf of Mexico states in Mexico	Colima, State of Morelos (CNMO 498, 1731, 2007)	Unknown reasons for introduction	Diverse bodies of water plus cenotes and micro-cenotes (Negrete Yankelevich, 1998)	Potential pest
Thiaridae	*Tarebia granifera* (Lamarck, 1822)*	Madagascar India, Asia (Pace, 1973)	Naranjo-García et al., 2005. Chiapas, Michoacán, Oaxaca, Tabasco, Veracruz (CNMO 1616, 1707, 2051, 2191, 2557, 2746, 2751, 2831, 2832, 3240, 3295, 3315, 3348, 3467, 3507, 3562, 3693, 3700, 3701, 3749, 3810, 3914)	Aquarium trade / possible transport by birds (Naranjo-García non published data)	Diverse bodies of water, ca. 1.5 m of depth (Chianotis et al., 1980; Appleton et al., 2009)	Pest

(Continued)

Table 2. (Continued)

Family	Species	Origin	Source/ record CNMO	Vectors	Habitat	Impact
	Melanoides tuberculata (Müller, 1774)*	Africa, Asia (Pace, 1973)	Abbott, 1973; Contreras-Arquieta and Contreras Balderas, 2000. Baja California Sur, Coahuila, Chiapas, Colima, Guerrero, Jalisco, Michoacán, Oaxaca, Quintana Roo, San Luis Potosí, State of Morelos, Tabasco, Tamaulipas, Veracruz, Zacatecas (CNMO 18, 288, 293, 296, 300, 420, 430, 431, 442, 580, 583; Mexico City: CNMO 683, 709-718, 725, 726, 813, 1169, 1236, 1088, 1376, 1617, 1678, 1680, 1683, 1699, 1714, 1867, 1926, 1954-57, 2020, 2050, 2052, 2055-56, 2058, 2061, 2071, 2168-71, 2174-76, 2187, 2189, 2192-93, 2206, 2213-15, 2478, 2554-58, 2561, 2565, 2639, 2753, 2763, 2832, 3086, 3088, 3203, 3256, 3258, 3260, 3301, 3384, 3481, 3534, 3552, 3764, 3880-82)	Aquarium trade	Diverse bodies of water	Pest
Lymnaeidae	*Radix auricularia* (Linnaeus, 1758)*	Europe, North of Asia	Böhm, 1983, Hidalgo (CNMO 2218)	Aquarium trade?	Lakes w/ abundant vegetation abundant, old river arms (Welter-Schultes, 2012)	Unknown if is a potential pest
Planorbidae	*Amerianna carinata* (H. Adams, 1861)**	Australia	Specimens caught at the USA-Mexico border, place of dwelling unknown (Robinson, 2014, pers. comm.)	Aquarium trade?	River shores, temporal bodies of water w/ abundant vegetation	Unknown if is a potential pest

(Continued)

Table 2. (Continued)

Family	Species	Origin	Source/ record CNMO	Vectors	Habitat	Impact
	Helisoma duryi (Wetherby, 1879)	Florida	Mexico City (CNMO 758)	Aquarium trade?	Shallow water bodies near to human beings	Can reach abundant populations, unknown if is a potential pest
Cyrenidae	*Corbicula fluminea* (Müller, 1774)*	Asia	Hillis and Mayden, 1985, Contreras-Arquieta et al., 1995. Colima, Chiapas, Chihuahua, Durango, Jalisco, Michoacán, Nayarit, Oaxaca, San Luis Potosí, Sonora, Veracruz, Zacatecas (CNMO 299, 301, 314, 440, 443, 495, 689, 771, 799, 1163, 1679, 1681-82, 1684-85, 1690, 1692, 1700, 1705, 1720, 1735, 1857, 2097, 2164-67, 2597, 2840, 2827, 2940, 2942, 3065, 3177, 3179, 3284, 3385, 3773, 3847)	As food	Diverse bodies of water	Pest
Dreissenidae	*Dreissena polymorpha* (Pallas, 1771)*	Black sea and Caspian Sea (Leentvaar,1971)	Veracruz (CNMO 3257, 6060)	Ballast water	Rivers and lakes	Potential pest in Mexico

Table 3. Exotic terrestrial mollusks recorded in Mexico: place of origin, references or sources, means of introduction (vector), habitat and impact with regard to the damage they may cause;* = Naturalized,** = data provided by David G. Robinson.

Family	Species	Origin	Reference/Source	Vector	Habitat	Impact
Veronicellidae	*Sarasinula plebeia* (Fischer, 1868)*	New Caledonia	Andrews and Dundee, 1987; Naranjo-García et al., 2007. Colima, Chiapas, Jalisco, Oaxaca, Querétaro, San Luis Potosí, Sinaloa, State of Morelos, Tabasco, Veracruz, Yucatán (CNMO 63, 173, 271, 414, 553, 556, 559, 561, 635 - 641, 1072, 1656, 1727, 1762, 1763, 4425, 4539, 4933, 4934, 4936, 4937, 4938, 5013, 5014)	Plants transportation	Diverse habitats reaching 1000 m of altitude (Caballero et al., 1991)	Pest
	Phyllocaulis gayi (Fischer, 1871)	South America (Chile)	Baker, 1925	Plants or goods transportation	Damp forests (Stuardo and Vargas-Almonacid, 2000)	Unknown if is a potential pest
Punctidae	*Paralaoma servilis* (Shuttleworth, 1852)*	Canary Islands/ Oceania? (Rumi et al., 2010)	Rivera-García, 2013, Mexico City (CNMO 2803, 3224, 4408, 4409, 4410, 4411, 4412, 4413, 4414, 4416, 4429, 4715)	By human activities (Thompson, 2011)	Diverse habitats, pine and olive forests, disturbed sites and gardens (Štamol and Kletečki, 2009; Welter-Schultes, 2012)	Unknown if is a potential pest
Milacidae	*Milax gagates* (Draparnaud, 1801)	W Mediterranean	Baker, 1930, Roth and Sadeghian, 2003. Mexico City, State of Morelos (CNMO 2211, 3449, 5042)	Plants or goods transportation	Cultivated fields, forests and shrub areas (Welter-Schultes, 2012)	Pest
Boettgerillidae	*Boettgerilla pallens* Simroth, 1912	W Caucasus	Mexico City, Puebla (CNMO 1520, 5554)	Plants transportation	Damp forests, gardens and disturbed sites. It lives deeply buried in the soil (South, 1992, Mc Donnell et al., 2014, Welter-Schultes, 2012)	Garden and Green houses in the United Kingdom (Welter-Schultes, 2012)
Arionidae	*Arion circumscriptus* Johnston, 1828*	NW and Central Europe to N Italia	Mexico City (CNMO 020, 3470)	Plants transportation	Cold and damp forests, crops fields and gardens (Welter-Schultes, 2012)	Unknown if is a potential pest

(Continued)

Table 3. (Continued)

Family	Species	Origin	Reference/Source	Vector	Habitat	Impact
	Arion intermedius Normand, 1852**	Europa	Specimens caught at the USA and Mexico border, place of dwelling unknown (Robinson, 2014, pers. comm.)	Plants transportation	Grass fields and rubbish sites (South, 1992)	Potential pest
Agriolimacidae	*Deroceras invadens* Reise, Hutchinson, Schunack, and Schlitt, 2011	Great Britain (Reise, Hutchinson, Schunack and Schlitt, 2011)	Mexico City (CNMO 3451) Specimens caught at the USA and Mexico border, place of dwelling unknown (Robinson, 2014, pers. comm.)	Forage cargos, materials for Green houses, nurseries, gardens and commercial vegetables (Reise et al., 2006)	Shaded places, with human influence (Welter-Schultes, 2012)	Pest
	Deroceras laeve (Müller, 1774)*, phallic form	Palearctic from Denmark (Thompson, 2011)	Martens, 1898: 348; Baker, 1930. Chiapas, Michoacán, State of Morelos, Durango, Mexico City (CNMO 59, 281, 284, 286, 298, 306, 3154, 4019, 4430)	Plants transportation	Diverse habitats: from tropical to subpolar (Welter-Schultes, 2012)	Pest
	Deroceras laeve (Müller, 1774)*, aphallic form	Palearctic	Martens,1898, Baker, 1930 (Desierto de los Leones, Necaxa). Coahuila, Jalisco, Michoacán, San Luis Potosí, State of Mexico, Veracruz (CNMO 278, 279, 627, 1080, 1081, 1635, 1637, 2672, 3153, 3390, 3394, 3447)	Plants transportation	In Spain close to human surroundings; in crop fields and at side of roads (Castillejo, 1998)	Pest
	Deroceras reticulatum (Müller, 1774)*	Europe	Mexico City, State of Mexico (CNMO 7, 21, 435, 560, 3264, 3413, 3420, 3437, 3440, 3442, 3717)	Plants transportation	Near to human surroundings (Welter-Schultes, 2012).	Serious Pest
Limacidae	*Lehmannia valentiana* (Ferussac, 1821)*	Iberic Peninsula	Aguascalientes, Coahuila, Mexico City, Michoacán, Sinaloa, State of Mexico, Veracruz (CNMO 282, 287, 289, 291, 292, 294, 305, 306, 734, 1068, 1768, 2210, 3151, 3231, 3353, 3393, 3404, 3439, 3452, 3856)	Plants transportation	Near to human surroundings, in Green houses (Kerney and Cameron, 1996; Welter-Schultes, 2012)	Pest

(Continued)

Table 3. (Continued)

Family	Species	Origin	Reference/Source	Vector	Habitat	Impact
	Limacus flavus (Linnaeus, 1758)*	Europe	Baker, 1930 (Puebla, Huachinango) Chihuahua, Jalisco, Mexico City, State of Mexico (CNMO 557, 1729, 1732, 3158, 3354, 3396, 3398, 5098)	Plants transportation	Near to human surroundings, wet walls of old buildings, and basements (Welter-Schultes, 2012)	Pest (possibly because of its numerous egg masses 40-60)
	Limax maximus Linnaeus, 1758*	Europe	Desierto de Los Leones and Mexico City, State of Mexico (CNMO: 29, 113, 3155, 3352, 3453, 3485, 3492, 3860)	Plants transportation	Sheltered damp places, at night climb trees; in compost, gardens, cemeteries, etc. (Welter-Schultes, 2012)	Potential Pest (Welter-Schultes, 2012)
Valloniidae	*Vallonia costata* (Müller, 1774)	N Africa and Europe to Central Asia	Mexico City (CM 143801, CNMO XXX)	Plants transportation	Among grasses, at side of roads (Hubricht, 1985); open and dry sites, around calcareous soil, rocky places and dunes of sand, scarce shaded places (Welter-Schultes, 2012).	Unknown if is a potential pest
	Vallonia excentrica Sterki, 1893	Europe/ North America	Cuernavaca, State of Morelos (Pilsbry, 1948); Mexico City (ENG 022, 188, 195, 237)	Plants transportation	Among grasses, at side of roads (Hubricht, 1985); open and dry sites rocky places and dunes of sand (Welter-Schultes, 2012)	Unknown if is a potential pest
Ferussaciidae	*Cecilioides acicula* (Müller, 1774)	Europe	Mexico City (ENG 236)	Plants transportation	Two meters' depth into sub- soil, frequent around 20 -40 cm., in rocky areas among leaf litter, roots, or river detritus. Non found alive (Welter-Schultes, 2012)	Potential pest

(Continued)

Table 3. (Continued)

Family	Species	Origin	Reference/Source	Vector	Habitat	Impact
Subulinidae	*Opeas hannense* (Rang, 1831)**	Cape Verde, Village of Hann (Rang, 1831; Pilsbry, 1906)	Specimens caught at the USA and Mexico border, place of dwelling unknown (Robinson, 2014, pers. comm.)	Plants transportation	Diverse tropical and subtropical habitats; below rocks, plant detritus and humus (Pilsbry, 1946)	Unknown if is a potential pest
	Subulina octona Bruguière, 1789	South America (possibly) (Thompson, 2011)	Veracruz and Tabasco (Martens, 1890- 1901). Sinaloa, State of Morelos, State of Mexico (CNMO 1164, 1664, 1758, 2482).	Possibly with plants (Pilsbry, 1946)	Found frequently in nurseries	Unknown if is a potential pest
	Rumina decollata (Linnaeus, 1758)*	Mediterranean	Chihuahua, Coahuila, Durango, San Luis Potosí, Hidalgo, Jalisco, Puebla, State of México (CNMO 297, 316, 787, 1069, 1074, 1076, 1386, 1686, 1738, 1766, 1993, 2939, 2941, 2943, 3293, 3397, 3399)	Plants transportation	Arid surroundings (De Francesco and Lagiglia, 2007). Abundant in crop fields (Correa-Sandoval, 1993)	Could impact populations of native mollusks
Streptaxidae	*Huttonella bicolor* (Hutton, 1834)	Mirzapur (Hutton, 1834; Thompson, 2011), according to J.C. Bequaert from Africa (van der Schalie, 1948)	North of Veracruz (Correa-Sandoval, 1999)	Possibly by plants transportation	Near human surroundings (Annandale and Prashad, 1920; Pilsbry, 1926), gardens, crop fields, secondary forests (Vermeulen, 2007).	Could impact populations of native mollusks
Oxychilidae	*Oxychilus draparnaudi* (Beck, 1837)*	Europe	Mexico City [Distrito Federal] (CNMO 015, 308, 433, 514, 518, 525, 829, 2816, 2817, 2818, 3225, 3230, 3721, 3726, 3730, 3857, 3858, 3862) (CM 143802)	Plants transportation	Damp areas, below leaf litter, rocks in semi open and open environments; gardens, green houses near humans (Welter-Schultes, 2012)	Could impact populations of native mollusks (predator)

(Continued)

Table 3. (Continued)

Family	Species	Origin	Reference/Source	Vector	Habitat	Impact
Camaenidae	*Zachrysia auricomya havanensis* Pilsbry, 1894	Cuba, La Habana.	Quinta in Mérida, Yucatán (Bequaert and Clench, 1936: 64)	Plants transportation	Dry sites with scarce shade, loose rock places, gardens; low shady places with scarce height (Pilsbry, 1929)	Unknown if is a potential pest; potential vector of veterinary diseases
Gastrodontidae	*Zonitoides arboreus* (Say, 1816)*	Philadelphia, Pennsylvania, USA	Puebla, Necaxa (Baker, 1930); Mexico City (ENG 24, CNMO 3229)	Plants transportation	Damp forests (Welter Schultes, 2012), below bark, tiles, rocks; eats sugar cane roots (Pilsbry, 1946:483)	Potential pest (Hawaii a pest) (Hollingsworth and Armstrong, 2003)
Helicidae	*Cantareus apertus* (Born, 1778)	Africa and Europe, Mediterranean (Roth and Chivers, 1980).	Mexico without more data (Roth and Sadeghian, 2003: 35)	Plants transportation	Warm and dry sites (Marasco and Murciano, 1986) among shrubs, near crop fields, gardens (Welter-Schultes, 2012).	Potential pest
	Cornu aspersum (Müller, 1774)*	Europe	Recorded by Humboldt around 1803 (Martens, 1890-1901); Mexico City (Pilsbry, 1891); Martens, 1890-1901). Mexico City, State of México, Tlaxcala, Puebla, Hidalgo, Michoacán, Veracruz, Chiapas (CNMO 22, 24, 34, 79, 153, 161, 269, 272, 280, 307, 330, 408, 436, 437, 438, 439, 444, 445, 453, 460, 506, 517, 647, 649, 777, 779, 780, 781, 810, 1242, 1331, 1746, 1747, 1748, 1749, 1750, 1751, 1756, 1812, 1997, 2340, 2622, 2760, 2805, 3083,3182, 3232, 3343, 3632, 3640, 3643, 3527, 3714, 3716, 3728)	Plants transportation	Dry sunny places, with scattered vegetation, or near the sea (Marasco and Murciano, 1986)	Pest in crops, gardens and orchards (possibly for the numerous eggs)

(Continued)

Table 3. (Continued)

Family	Species	Origin	Reference/Source	Vector	Habitat	Impact
	Theba pisana (Müller, 1774)**	Mediterranean	Specimens caught at the USA and Mexico border, origin unknown (Robinson, 2014 pers. comm.)	Plants transportation	Near the coast, Sandy areas, warm environments; goes dormant under the sun (Welter-Schultes, 2012)	Pest, possibly because the numerous eggs (40-80) (Welter Schultes, 2012)
	Eobania vermiculata (Müller, 1774)**	Mediterranean	Specimens caught at the USA and Mexico border, origin unknown (Robinson, 2014 pers. comm.)	Plants transportation	Diverse dry environments; near the sea or field crops (Welter-Schultes, 2012)	Potential pest (possibly by the number of eggs 60-80) (Welter Schultes, 2012)
	Otala lactea (Müller, 1774)**	SW Europe, Morocco	Specimens caught at the USA and Mexico border, origin unknown (Robinson, 2014 pers. comm.)	Plants transportation	Around shrubs of rocky areas; open spaces (Welter-Schultes, 2012)	Potential pest
Cochlicellidae	*Prietocella barbara* (Linnaeus, 1758)**	Mediterranean	Specimens caught at the USA and Mexico border, origin unknown (Robinson, 2014 pers. comm.)	Plants transportation	Near the sea, dry and Sandy, or sand dunes covered with grasses (Welter-Schultes, 2012)	Potential pest [in cultivated grass]
Braydaenidae	*Bradybaena similaris* (Férussac, 1822)**	Eastern Asia, China, SE Asia, Japan (Schileyko, 2004)	Specimens caught at the USA and Mexico border, origin unknown (Robinson, 2014 pers. comm.)	Plants transportation	In disturbed places, forests, gardens, near urban environments (Vermeulen and Whitten, 1998)	Potential pest [pest in grape orchards]
Lauriidae	*Lauria cylindracea* (Da Costa, 1778)**	W Europe and Mediterranean	Specimens caught at the USA and Mexico border, origin unknown (Robinson, 2014 pers. comm.)	Plants transportation	In forests, among wet rocks. In Crimea abundant in semi-dry areas. In Portugal in moss; below rocks, leaf litter, bark damp shady places (Welter-Schultes, 2012)	Unknown if is a potential pest

Table 4. Species introduced in Mexico per region of origin and percent which they represent.

Origin	No.species	Percentage
Europe	15	26.70
Asia	8	14.20
North America	5	9.00
Mediterranean	5	8.90
Caribbean, Antilles	4	7.00
South America	4	7.00
Africa and Europe	3	5.35
Europe, Asia	2	3.80
W Africa	2	3.80
Australia, New Caledonia	2	3.80
Pacific Central America	1	1.80
Indo Pacific	1	1.80
Bermudas	1	1.80
Eastern Mexico	1	1.80
Africa, Asia	1	1.80
Palearctic	1	1.80
Africa, Europe, Asia	1	1.80
Holoarctic	1	1.80

on Lobos Reef, Veracruz. Since this species can survive as an ectoparasite on various invertebrates, it could have been introduced with species such as *C. virginica* as far back as the last century. Its survival would have been favored by the diversity of species that exist on the reef plain of Veracruz; hence, *B. bisuturalis* is likely to be more common in the region than suggested by this single record. Its planktotrophic larvae (Robertson and Mau-Lastovicka, 1979) would enable *B. bisuturalis* to be transferred in ballast water and install itself on various macrobenthic species. Unfortunately, it has not been recorded as introduced to Mexico, perhaps as it is considered by some to be native/naturalized, or because the research has been limited to compilation of a simple checklist. *Boonea* species can seriously affect oyster fisheries and aquaculture (Wilson et al., 1988; Cumming and Alford, 1994), so that establishment large populations of *B. bisuturalis* should be considered as a potential threat to populations of the oysters in Mexico.

Cenchritis muricatus (Linnaeus, 1758) is common in the Caribbean, southern Florida, and the Bahamas (Clench and Abbott, 1942; Abbott, 1954; Trussell, 1997), where it is distributed from the shoreline to a depth of about 3.6 m (Lang et al., 1998; Emson et al., 2002). It withstands desiccation and extreme heat at low tide. It was first recorded in 1992 in the northern part of the Gulf of California.

Diala albugo (Watson, 1886) is a small gastropod of the Indo-Pacific that, as evidenced by its protoconch, possesses a planktotrophic larva (Ponder and De Keyzer, 1992). It was included by Aguilar-Estrada et al. (2014) in a checklist of a reef community in Veracruz that consisted mainly of dead specimens. It is not officially registered as introduced in Mexico and, because its identification is difficult, it is not included here nor in Table 1.

Nudibranch gastropods (Heterobranchia) of the genus *Anteaeolidiella* Miller, 2001, *A. foulisi* (Angas, 1864), *A. cacaotica* (Stimpson, 1855), and *A. indica* (Bergh, 1888), recorded in Mexico (Hermosillo et al., 2006; Hermosillo and Gosliner, 2008; Hermosillo, 2009), are not considered here because the systematics of the Aeolidiidae has been undergoing review on the basis of morphological and molecular data (Carmona et al., 2013); those studies will affect the distribution records of previously unrecognized, potentially circumtropical species (Ángel Valdés, personal communication).

Freshwater Mollusks

The gastropod *Tarebia granifera* (Lamarck, 1816) from Madagascar, India, and Asia, is ovoviviparous, reproducing by parthenogenesis, and matures to a short length (5.5 to 8.0 mm) (Appleton et al., 2009), features that are advantageous in competing with native species following invasion events. In other countries, it can displace native species that display similar habitat requirements, such as those in the genus *Pachychilus* Lea, 1850. In the Caribbean and South America, it displaces and/or regulates populations of species in the genus *Biomphalaria* Preston, 1910 (Pointier and Augustin, 1999; Pointier et al., 1998). Its high reproductive potential allows it to quickly invade bodies of water where it is introduced, and to literally modify its physical conditions; in Mexico, it is considered an invasive species (CONABIO, 2015).

Melanoides tuberculata (O.F. Müller, 1774) (gastropod) and *Corbicula fluminea* (O.F. Müller, 1774) (bivalve), both originating from Asia, are widely distributed in Mexico (Contreras-Arquieta et al., 1995; Contreras-Arquieta, 1998; Contreras-Arquieta and Contreras-Balderas, 1999) and are recognized as invasive species (CONABIO 2015). *Melanoides tuberculata* is ovoviviparous and reaches maturity at about 3.5 mm or in about six months (Gutiérrez-Amador et al., 1995; Appleton et al., 2009), which has allowed it to produce large populations very quickly. *Corbicula fluminea* tolerates changes in environmental conditions (Avelar et al., 2014), feeds on suspended material by filtering and through pedal feeding, and influences the abundance of surrounding benthic and pelagic fauna, as well as the organic-matter cycle (Hakenkamp et al., 2001). It may be possible that *C. fluminea* competes for space with native clams of the family Unionidae (Britton and Fuller, 1979).

Pomacea canaliculata (Lamarck, 1822) originally from Argentina, South America (Cowie and Thiengo, 2003), was registered for the first time in the wild in Mexico in 2013. It is presumed that the population in Mexico came from the Colorado River, since it was located in 2005 in that river in Yuma, Arizona, and the Colorado River continues its course in Mexico (Campos et al., 2013). In addition, specimens of apple snails found in California and Arizona have been confirmed to be *P. canaliculata* based on 46 unique mtDNA haplotypes (Rawlings et al., 2007). The presence of non-native apple snails is of great concern due to their ability to spread fast and because they are recognized as agricultural pests (e.g., in rice fields in Asia). Invasion of exotic apple snails poses a treat to marshland habitats, with the possibility of changes in their diversity and ecological processes, as happened in Laos, South East Asia (Carlsson and Lacoursière, 2005; Rawlings et al., 2007). Apple snails are listed among the world's 100 worst invasive species (Lowe et al., 2000). Its amphibian status and herbivore habits are conducive to its establishment and possibly to its success in environments such as rice fields in Japan, Philipines, China, and other Asiatic countries (Thiengo et al., 1993; Cowie et al., 2006; Rawlings et al., 2007; Ziyuan and Yuansheng, 2012). From the human health point of view, *P. canaliculata*, along with various freshwater or terrestrial molluscan species, is an intermediate host of the low specific host nematode *Angiostrongylus cantonensis* (lung worm); in nature its definite hosts are several species of rodents. *Pomacea flagellata* (Say, 1829), a native of the Gulf of Mexico states, was introduced to the Pacific coast. Its present distribution has facilitated the expansion of the distribution of the snail-eating kite *Rostrhamus sociabilis major* Nelson and Goldman, 1833 by about 900 km into the Pacific region (Hernández-Vázquez et al., 2013). In addition, the "carrao" *Aramus guarauna dolosus* Peters, 1925 (naturally distributed in the States of Veracruz, Chiapas, and Yucatan) is now found in Laguna del Tule, Barra de Navidad, Jalisco, on the Pacific coast (Hernandez-Vázquez et al., 1999; Palomera-García et al., 2006). Dispersals of introduced of species may affect native species of birds in the longer term.

Pomacea diffusa Blume, 1957, a species originally from the region of Santa Cruz, Bolivia (Cowie and Thiengo, 2003) has been intercepted in shipments arriving in the USA from an unspecified part of Mexico (David Robinson, personal communication). As Howells et al. (2006) pointed out, "introduced species pose a serious threat to native biodiversity, second only to habitat loss".

The Zebra Mussel *Dreissena polymorpha* (Pallas, 1771) is a great ecological threat (Schloesser and Schmuckal, 2012) and is among the 100 worst invasive species (Lowe et al., 2000). Young specimens have been found at two sites in the State of Veracruz: Río Tonalá, San José, and Río Coatzacoalcos, Napa Creek. (CNMO 3257: Las Choapas. Río Tonalá, San José. Veracruz; and CNMO 6060: Rio Coatzacoalcos, Arroyo Napa, Veracruz. So far, these are the first record of the species in Mexico.)

Freshwater species already naturalized in Mexico are: *Pomacea canaliculata*, *Pomacea flagellata* (in the western side of the country where it was not native), *Melanoides tuberculata*, *Corbicula fluminea*, *Tarebia granifera* and *Radix auricularia* (Linnaeus, 1758).

Terrestrial Mollusks

The veronicellid slug *Sarasinula plebeia* (P. Fischer, 1868), originally from New Caledonia (Gomes and Thomé, 2004), is gregarious, able to self-fertilize, and oviparous, attributes that favor its potential as invasive species. The species is thought to have displaced native counterparts in Central America (Caballero et al., 1991). It is a serious pest of assorted agricultural crops in the southern Catemaco Region, Veracruz (Naranjo-García et al., 2007), and of vanilla in the northern Veracruz State (Velázquez-Montes de Oca et al., 2014).

Phyllocaulis gayi (P. Fischer, 1871) is known to occur in Valdivia, Chile (Thomé, 1971, 1976). However, the species was recorded in the city of Mazatlán, Sinaloa, Mexico in by Baker (1925). Baker suggested that the introduction of the species was probable due to Mazatlán's status as one of the main Pacific ports in Mexico. In 2006, Naranjo-García visited the city of Mazatlán looking for veronicellid slugs, but was unable to confirm the occurrence of *P. gayi* (Naranjo-García et al., 2007). The record of *P. gayi* in Mazatlán was either a misidentification or, if it was present at that time, it did not succeed there.

Cornu aspersum (O.F. Müller, 1774), originally from Europe, tends to be gregarious and to produce large numbers of offspring, attributes that have made it an invasive pest in gardens in Mexico City (Ancona, 1947). They have also destroyed orchards and gardens elsewhere in Mexico (María Villaroel, personal communication), as they have done in other countries (Apablaza, 1984; Cowie, 2000). Introduction may be at the egg stage or as juveniles on imported plants; it was re-introduced into Mexico (1991, CNMO 153) in imported strawberry seedlings, and has become a pest on cabbage crops in the State of Michoacán (Naranjo-García, unpublished data).

With regard to slugs, *Boetgerilla pallens* Simroth, 1912 (Table 3) is believed to be a pest in gardens and greenhouses in Europe (Welter-Schultes, 2012). Judging by their background record in other places of the world, *Deroceras reticulatum* (O.F. Müller, 1774), *Lehmannia valentiana* (Férussac, 1821), *Limacus flavus* (Linnaeus, 1758), *L. maximus* Linnaeus, 1758, *Rumina decollata* (Linnaeus, 1758) are potential pests on crops and gardens. *Deroceras reticulatum* is a very destructive slug that feeds on various cultivated plants (particularly at the seedling stage) such as cauliflower, cabbage, potato (Pilsbry, 1948; Castillejo, 1998). Hausdorf (2002) believes that *Deroceras invadens* Reise, Hutchinson, Schunack and Schlitt, 2011 is a serious pest.

Some authors consider *Deroceras laeve* (O.F. Müller, 1774) to as introduced in Mexico. However, there are fossil shells of what some believe to be this species of slug in Canada, the USA, and Mexico (El Cedral, San Luis Potosí; Olivera-Carrasco, 2007). If that is the case, the species has then been in North America since the Pleistocene. In Mexico, its two morphs are present, phallic (=euphallic) and aphallic. The species is well-suited with diverse life history traits that ensure it leaving descendants: it has a short life cycle, presents the two morphs, auto-fertilize, and, in rare occasions, present outcrossing. It is also tolerant of diverse ecological regimens and, under appropriate conditions, can reproduce all year long (Gómez, 2001; Jordaens et al., 2006). *Deroceras laeve* has been observed that become a pest in green houses (Wiktor, 2000).

The snail *Rumina decollata* in the area of Santiago, Nuevo León has been associated with crops of squash, onion, and cucumber (Correa-Sandoval, 1993).

Terrestrial species are *Sarasinula plebeia*, *Cornu aspersum*, *Paralaoma servilis* (Shuttleworth, 1852), *Arion circumscriptus*, *Deroceras laeve*, *Deroceras reticulatum*, *Lehmannia valentiana*, *Limacus flavus*, *Limax maximus*, *Rumina decollata*, *Oxychilus draparnaudi* (Beck, 1837) and *Zonitoides arboreus* (Say, 1816).

CONCLUSIONS

There are 56 species of mollusks introduced in Mexico. These records are confirmed by live material deposited in collections and from the literature. This number may increase as searches intensify. Until now, such information is contained in works consisting mostly of lists that do not indicate the status of the species treated and whether they are exotic (non-native) or invasive (established and naturalized). Species intentionally brought for aquaculture may contribute to the introduction of associated, potentially invasive species. Examples of this potential are mollusks with a byssus (mussels) and with live epifauna on the upper surface of an oyster.

Between 1980 and 2009, fewer than five authors have recorded living exotic species on the Mexican Pacific coast. Existing legislation should be applied rigorously or improved (Ortiz-Monasterio, 2014). Administration and management of ports and customs must protect the national territory and conserve biodiversity. Introduction of species can harm life cycles of other taxa, with direct damage to human health and the national economy.

Some of the mollusks here mentioned may succumb under the effects of climate change, but others may survive and colonize areas where they currently cannot survive due to the constraints imposed by the climate. Hence, it is important to know the status of each species, and to monitor their presence and effects over habitats and native wildlife at national level. Molecular studies will further add to the knowledge of the systematics and population structure of these alien species.

Mollusks are among the most biodiverse groups of invertebrates, and the creation of a Mexican monitoring network devoted to exotic species and their effects would help to protect native endemic species and could examine with scientific basis the effects of introduced organisms on human health and environment.

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